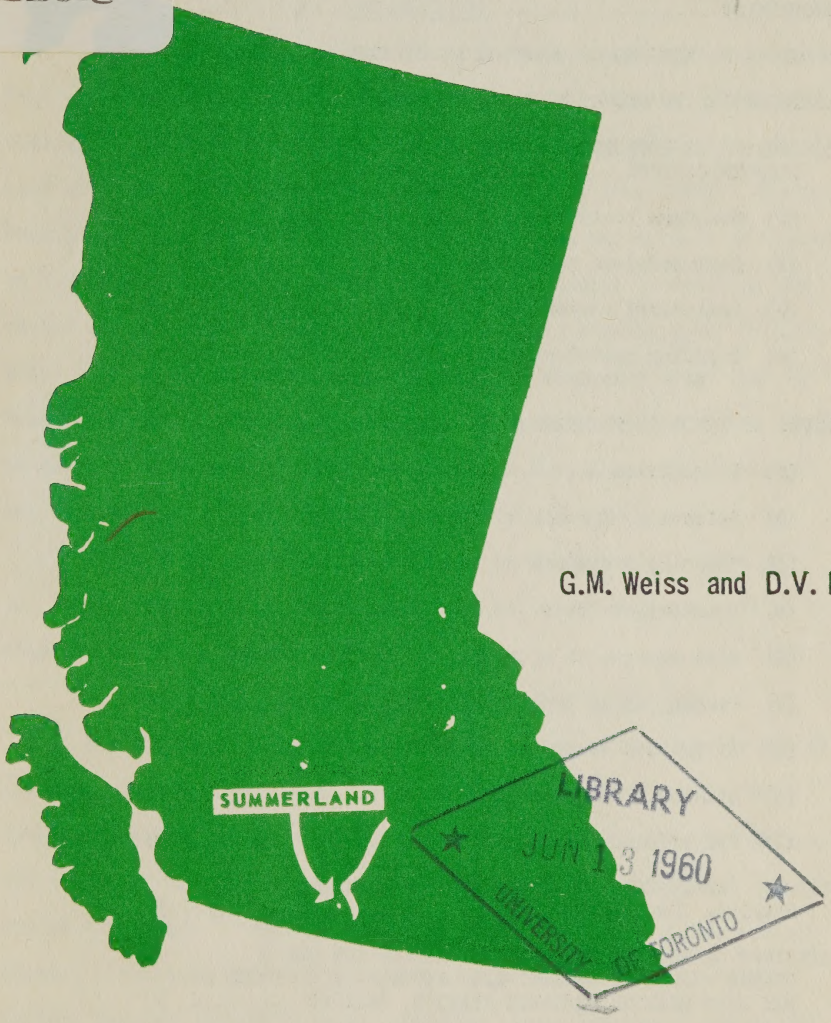
GROWING APPLE TREES ON DWARFING ROOTSTOCKS



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by

G. M. Weiss[1] and D. V. Fisher[2].

I. INTRODUCTION

Commercial apple plantings in North America traditionally have been grown on seedling rootstocks that produced large trees. Availability of relatively inexpensive land and labor tended toward development of an extensive rather than intensive type of orcharding. However, rising costs of labor and investment capital make the growing of apples on dwarfing rootstocks attractive from the standpoint of reducing the period between planting and full bearing and in reducing labor outlays. Since many of our existing apple orchards are at an age where they no longer provide a satisfactory return to the grower, consideration must be given to a renewal or replacement program that will bring the orchard back into profitable production as quickly as possible.

It is the purpose of this bulletin to present information on the culture of apples on dwarf rootstocks in the Okanagan as well as in other parts of the world.

II. HISTORICAL BACKGROUND OF DWARFING ROOTSTOCKS

The technique of controlling growth of fruit trees by the use of specific rootstocks was known centuries ago. Some four or five different "Paradise" stocks and at least a dozen different "Doucin" clones, often more or less mixed, were propagated in Europe as dwarfing rootstocks for apples. That mixtures existed, or that some of these vegetatively propagated Paradise and Doucin apple rootstocks were sold in various European countries under different names, was first recognized

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by European horticulturists about 1910. Independent studies were started in Germany, England and Holland around 1910 to describe and classify these various stocks. At the East Malling Research Station, England, studies with the Paradise apple rootstocks were begun in 1912. The first report, published by Hatton in 1917, proved the existence of a number of vegetatively propagated apple rootstocks having a wide range of vigour. Many of these rootstocks were at that time being propagated and distributed in England as Paradise stocks. Hatton identified and described each and selected a typical plant to which he gave a Roman numeral followed by the name of the clone from which it was selected. He then proceeded to increase each selected type and determine the rooting qualities as well as growth effects upon various scion varieties. Sprenger, in Holland, also observed the occurrence of mixtures in apple stocks propagated under a given name. Beginning in 1914 he brought together and identified the components of a total of 48 collections of vegetatively propagated apple rootstocks grown as "Paradise" and Doucin in Holland, Belgium and France. His studies and findings agreed closely with those of Hatton, namely that mixtures occurred not only among stocks under a given name, but that the names used for given clones differed.

The East Malling nomenclature as suggested by Hatton, was adopted and the East Malling series came into being. This classification of rootstocks provided the stimulus for the development of other specialized rootstocks. An example is the Malling-Merton apple series introduced principally to provide trees with better resistance to root woolly aphids and better anchorage. The Swedish A2 clone was introduced for hardiness, and a series of other hardy clones have come from Kansas along with the Maurer dab series from Germany. These stocks have various

vigour ratings. Projects are also underway to develop improved apple rootstocks at the New York Experiment Station in Geneva, at the Plant Research Institute, Ottawa, and at the Summerland Research Station. The Summerland series was selected for cloning ability, resistance to crown rot and frost hardiness.

III. CLASSIFICATION OF STOCKS BY VIGOUR GROUPS

There is a wide range of clonal rootstocks available which will produce trees varying in mature size from four feet in height (Fig. 1) up to the strong growing trees similar to those on seedling rootstocks which may attain a spread of 40 feet or more. In this bulletin the rootstocks which are most likely to be used in commercial plantings are grouped in Table I into four vigour groups: standard, semi-standard, semi-dwarf and dwarf.

Table I. Classification of rootstocks according to four levels of vigour.

Vigour classification	Rootstocks
Standard	Seedling, E.M. XVI, E.M. XXV, and M.M. 109.
Semi-standard	E.M. II, M.M. 104 and M.M. 111.
Semi-dwarf	E.M. IV, E.M. VII, and M.M. 106.
Dwarf	E.M. IX, E.M. 26 (and E.M. VIII used as a stempiece.)

IV. DESCRIPTIONS OF ROOTSTOCKS WITHIN THE FOUR VIGOUR CLASSIFICATIONS

A) Standard rootstocks:-

Seedling:- As the name implies, seedling stocks are grown from open pollinated seed of commercial varieties of apples. Winesap and Delicious seedlings have been most commonly used in the northwest but are relatively tender and are susceptible to crown rot. McIntosh seedlings are more hardy and are not as susceptible to crown rot. Although

Fig. 1. McIntosh on E.M. 3426 rootstock, one of the smallest of the East Malling IX cross series. This tree is fruiting in the third season after planting and will remain very small. Director, Dr. W.H. Upshall of the Hort. Exp. Station, Vineland, stands by the tree.

many British Columbia nurseries are using McIntosh seedlings for the majority of their standard stocks, there are some trees produced on seedlings of Antonovka and hardy crabs. Trees on seedling stocks are vigorous and require no staking. One of the main disadvantages of seedlings from named varieties is that only one parent is known. Thus one set of seedlings from a known seed parent can vary greatly from that of another depending on the hardiness of the pollen parent.

E.M. XVI: This rootstock produces trees of comparable size to those grown on seedling stocks. Trees grown on this stock have good anchorage, but exhibit no advantages over trees on seedling stocks and are susceptible to crown rot.

E.M. XXV. E.M. XXV produces vigorous, crown rot resistant,

moderately well anchored trees, which come into bearing earlier than the other vigorous stocks described here.

M.M. 109. M.M. 109 is a vigorous growing rootstock which produces standard sized trees. This stock is resistant to crown rot and woolly aphid but is less well anchored than E.M. XVI or E.M. II and hence may require some temporary staking in the early years of growth. In tests at the East Malling Research Station, trees on M.M. 109 have yielded slightly better than trees on E.M. XVI.

B) Semi-standard rootstocks

E.M. II. This rootstock produces a tree about two-thirds to three-quarters standard size. (Fig. 2). It is moderately well anchored but may need some temporary staking when the trees are young. E.M. II is slightly susceptible to crown rot and initiates earlier bearing in scion varieties than most standard stocks.

M.M. 104. M.M. 104 is extremely well anchored, requires no staking and is resistant to crown rot. Trees on this stock grow vigorously in their early years and produce early yields much greater than those of trees on E.M. II. Trees on this stock may be slightly larger than those on E.M. II.

M.M. 111. This is a crown rot resistant stock comparable in size to Malling II but has slightly poorer anchorage and thus requires staking, at least in the early years of growth. It induces heavier early bearing than E.M. II though not as heavy as M.M. 104.

C) Semi-dwarf rootstocks

E.M. IV. E.M. IV is a semi-dwarfing rootstock which makes a tree approximately one-half standard size. It induces very heavy early bearing in the scion variety, heavier than any of the other East Malling stocks and almost as heavy as that induced by M.M. 104.

Fig. 2. Delicious on E.M. XVI (standard size stock) and on E.M. II (semi-standard size stock) at 20 years of age. Based on trunk size and tree spread the E.M. II tree is about two-thirds the size of the E.M. XVI tree.

It is considered better adapted to light soils than E.M. VII or M.M. 106. However it is very poorly anchored with a shallow, brittle root system and therefore requires permanent staking throughout the life of the tree. This latter characteristic has tended to make E.M. IV somewhat less popular than the other East Malling stocks.

E.M. VII. E.M. VII produces a tree a little smaller than E.M. IV, but still in the semi-dwarf class. Although it does not induce as early bearing as E.M. IV the early yields are still much heavier on this stock than on E.M. II and most of the more vigorous rootstocks. This rootstock is slightly susceptible to crown rot and has only fair anchorage thus requiring temporary staking at least in the early years of growth.

M.M. 106. This rootstock, on good soils, produces a tree similar in size to that on E.M. VII but on light soils intermediate bet-

ween trees on E.M. VII and E.M. IX. However it does not produce the undesirable suckers around the base of the tree that occur on E.M. VII. In tests at the Summerland Research Station this rootstock has proven susceptible to crown rot, although latest releases from East Malling Research Station in England state that this rootstock is resistant to several strains of the crown rot organism common to that area. This point will be clarified by further tests at the Summerland Research Station in the near future. Like E.M. VII, this rootstock has only moderately good anchorage and therefore will require temporary, if not permanent, staking. Yield records from East Malling indicate that this rootstock induces approximately the same bearing characteristics as does E.M. VII. On light soils, however, trees on M.M. 106 may be much smaller than trees on E.M. VII and actually would fall in the dwarf classification. Spacing and training methods in such instances would therefore have to be similar to those used for E.M. IX and E.M. 26.

D) Dwarfing rootstocks

E.M. IX. This stock is considered to be a full dwarfing stock producing trees which at maturity can be picked from the ground. It is very popular for use in the home garden and in Europe has been used extensively in commercial fruit culture. E.M. IX has been employed where various specialized training and pruning methods such as in hedgerows or cordon systems are used to initiate heavy early bearing of high quality fruit. Trees on E.M. IX can be grown as conventionally shaped trees similar to those on seedling rootstocks, but on a much smaller scale. Under this method, however, the main trunk of the tree will require permanent support using individual tree stakes, or wires running the length of the row. This stock is slightly susceptible to crown rot.

E.M. 26. This stock appears to be slightly more vigorous and better anchored than E.M. IX. It is the last named of the East Malling stocks being a selection from the new E.M. IX series of crosses. It is also the only rootstock which has been named from this series to date although some other still more dwarfing rootstocks have attracted attention in experimental work. In all probability the same type of tree will be produced on this rootstock as on the E.M. IX and the same staking and training methods will be applicable.

Use of E.M. VIII as a dwarfing stempiece. The use of E.M. VIII (Clark Dwarf) as a stempiece grafted in between a seedling rootstock and the scion variety has attracted attention as a means of reducing tree size without incurring the disadvantage of having to stake where trees are grown directly on full dwarfing stocks. (See Fig. 3). The degree of dwarfing is proportional to the length of the stempiece. A 12-inch piece is considered necessary to produce a tree similar to E.M. IX. Limited experiments at the Summerland Research Station have shown that satisfactory root anchorage and expected reduction in tree vigour were obtained where both E.M. VIII and E.M. IX have been used as stem pieces. The disadvantages of this method of tree dwarfing are extra cost of producing double worked trees and the presence of a semi-hardy section of trunk extending above snow line.

Many other new rootstocks are available but this list describes those which probably will be the most important commercially over the next several years. This does not mean that other clonal rootstocks may not be superior to those listed. However, it is advisable for the grower to avoid large plantings on other clonal stocks until they have proven themselves in experimental plantings. All stocks listed in Table I have proven themselves in experimental plantings and are suitable for planting on a commercial basis.

Fig. 3. Three-year-old Red Delicious tree on 6-inch stem-piece of E.M. VIII (Clark Dwarf) on seedling rootstock. The swollen portion is the E.M. VIII stem-piece. This method dwarfs tree while retaining firm root anchorage.

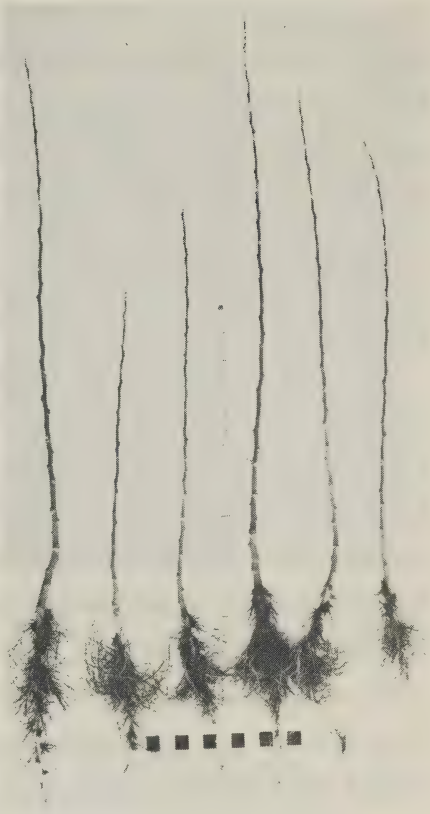


Fig. 4. Vegetatively propagated apple shoots at time of removal from stoolbeds. These shoots will be ready for budding to standard varieties in four to five months from time of lining out in the nursery row.

V. CULTURE OF TREES ON DWARFING APPLE STOCKS

A. Propagation

Clonal stocks are produced by four different methods. In Europe and England, until recently, the use of stoolbeds was the most popular method employed in the production of these stocks. However,

the use of layering beds and hardwood cuttings are both becoming popular. A method undergoing extensive experimentation both at Summerland and elsewhere involves the use softwood cuttings. In North America, the majority of clonal stocks are produced in layering beds as this method has produced consistently higher yields of rooted shoots. The following brief description of these four methods is included for the use of propagators who are interested in these stocks.

Stoolbeds

At the start, rooted shoots are planted deeply in good soil about three feet apart in rows four feet apart and cut back slightly below normal soil level. When shoots sent up from these mother plants have reached a height of five or six inches, soil is mounded up against them to one-half their height. When the shoots are ten or twelve inches high an additional two or three inches of soil is hilled up around them. In heavy soil, sawdust incorporated with an equal amount of soil has given excellent results as a mounding material because it keeps the stoolbed from compacting and increases the moisture-holding capacity of the soil.

After growth has stopped in the fall the stoolbeds can be opened and all shoots cut off to ground level, the cuts allowed to heal and the bed covered lightly for winter protection. Spring harvesting of the stoolbed which affords greater winter protection has also been used successfully in the Okanagan Valley. All shoots are removed at harvest time and those that failed to root are discarded. The rooted shoots (see Fig. 4) are planted out in the nursery. Yields are light the first year, but increase annually until maximum production is reached. Yields of 30,000 to 100,000 rooted shoots per acre have been obtained in England from mature stoolbeds, depending on type of rootstock, soil and growing season.

Fig. 5. Eleven-year-old Winesap trees on E.M. IX rootstock. These trees are spaced 8 feet apart in rows 15 feet apart and supported by wires on posts.

Fig. 6. Nine-year-old Delicious trees on E.M. IX rootstock. These trees are spaced 8 feet apart in rows 10 feet apart. The trees are so crowded it is impossible to use mechanical orchard equipment in this block.

Layering beds

In layering beds the plants are lined out much the same as in stool beds but one or two strong shoots are allowed to remain in the bed from each mother plant each year. These shoots are then pegged down horizontally in the spring and hilled up so that new shoots develop along the length of the layer. In the fall or spring when the bed is opened all the rooted shoots are removed. Of those that haven't rooted a few of the stronger shoots on each plant are layered to produce a new crop. This procedure is repeated each year.

Hardwood cuttings

Hardwood cuttings are taken in the fall after growth has ceased, but before heavy frosts have occurred. These cuttings are usually the basal portions of the new growth, the tip portion being discarded. The cuttings are bundled and stored at a high humidity at 45° F. in the dark. At this temperature, callus and root development carry on normally but there is no growth from the dormant buds. In the spring, if the climatic conditions in the area are satisfactory, these cuttings can be lined out in the nursery where a large proportion of them will root and develop into good nursery stock. In the Okanagan Valley, however, conditions are much too dry in the spring and summer for this method to be satisfactory. The cuttings, therefore, are put into beds where the temperature can be controlled and bottom heat applied to force rooting. The rooted shoots are lined out in the nursery later in the spring.

Softwood cuttings

Two growing seasons are required to produce nursery stock from softwood cuttings. Cuttings eight inches long are taken in June or early July from the top portion of vigorous, succulent shoots. The

basal portion of the cuttings is treated with a growth-promoting hormone such as indole acetic acid at 50 parts per million dispersed in talcum powder or clay and the cuttings placed in a rooting medium of sand, sand and peat moss, or vermiculite. A constant moisture supply must be maintained at all times to provide high humidity and to avoid drying of the rooting medium. Intermittent mist or constant mist equipment is usually desirable for this purpose. However, costly control equipment is often necessary to achieve desirable results. The rooted shoots are stored until spring and lined out in the nursery to be budded in August.

The larger rooted shoots produced by any of these methods are budded in the late summer and the smaller ones kept for budding in the following budding season. These stocks should be budded about five inches above ground in the nursery so that they may be planted deeply in the orchard and still have the union two inches above the soil level.

B. Selection of stock to plant

When considering new plantings the grower may choose from a wide selection of stocks of varying vigor. Several points should be considered in making this selection. The first and probably the most important is the ultimate size the trees will attain on a particular stock. For instance if the grower desires moderate sized trees which can be pruned and picked with a 10-foot ladder he should select a stock such as E.M. II or M.M. 104. If he wishes to use a very close planting of small trees which can be trained on wires or in hedge rows and can be handled from the ground, E.M. IX or Malling 26 would be the choice. (See Fig. 5). For trees intermediate in size between those two groups an E.M. VII or M.M. 106 rootstock should be used.

Earliness of bearing is another characteristic which should be given considerable attention when selecting a rootstock. For example, while M.M. 104 and E.M. II stocks will produce trees of comparable size, trees on M.M. 104 will greatly surpass trees on E.M. II in early production.

Disease resistance and anchorage must also be considered. For instance, crown rot resistance is much more important in a heavy soil than on a lighter soil. If anchorage is expected to be a problem M.M. 104 will provide a well anchored stock of the semi-standard type. With most of the other stocks, however, staking is advisable if wind conditions are unfavorable when the trees are either in crop or in full leaf.

C. Planting distances

Once the stock has been selected, planting distance is the next important consideration. There are three factors which influence planting distances, namely depth and quality of the orchard soil, the pruning and training method to be followed and vigour of the variety on the chosen rootstock. It would be beneficial for a prospective grower to examine established blocks of trees on various rootstocks in his own locality before deciding upon the exact planting distance which might be most suitable.

Correct spacing is extremely important for trees on dwarfing stocks. It is essential that the area planted has the maximum amount of bearing wood capable of producing high quality fruit when the trees reach maturity. The use of fillers may be profitable in dwarf and semi-dwarf plantings to make maximum use of land area and increase early yield. For example, trees on M.M. 104 which require a mature spacing of 24 x 24 feet could be planted with another M.M. 104 tree in the centre of each square to give an initial 17 x 17 foot spacing. By the time the filler

trees crowd and require removal they would have doubled the production of the planting. However, on E.M. II, a stock which comes into bearing a little later than M.M. 104, 20 x 20 feet might be a better spacing with E.M. VII fillers in the centres of squares or between trees in the row, making respectively a 14 x 14 feet or 20 x 10 feet square planting. The E.M. VII filler trees would increase early yields to bring a profitable return over their initial cost until the E.M. II trees reach profitable bearing. If the soil is of average quality 20 x 20 feet might be the final planting distance, but if the soil is heavy and the trees begin to crowd at this spacing, further removal of alternate diagonal rows would enable a final spacing of 28 x 28 feet.

It is recognized that spacing of dwarf trees is a controversial subject. In Continental Europe there is a tendency to plant trees very close because land is scarce and labor is relatively cheap for operating under close spacings. Thus, it is common to find plantings of trees on E.M. IX spaced at 6 x 11 feet. For Continental conditions that situation may be most economical. Restrictive pruning practices which result in small trees delayed in coming into full bearing necessitate close spacings in order to produce economic yields at the earliest possible date.

At the other extreme are recommendations from New York where the suggestion is to plant E.M. IX trees in rows 20 feet apart with trees 8 to 10 feet apart in rows. The semi-dwarf E.M. VII rootstock is recommended for planting in rows 30 feet apart and trees 15 feet in the row. With E.M. II rootstock, the planting distance recommended is 30 x 20 feet. Planting distances recommended in Ontario are even wider; for semi-standard stocks E.M. I and II, 35 x 35 feet; for E.M. IV, 35 x 35

feet; for a semi-dwarfing E.M. VII, 25 x 25 feet; for E.M. IX, 15 x 20 feet. On French Crab seedlings the planting distance recommended is 40 x 40 feet.

The recommendations from this Station represent something of a compromise between the two extremes. Our recommendations are based upon what is practical for the use of mechanical cultivating, spraying and hauling equipment. Thus, we believe that the minimum spacing between rows should be 15 feet for E.M. IX's, and for other stocks 20 feet or more. In Table No. 2 are summarized planting distances and number of trees per acre recommended by this Station. It will be noted that under the heading "Planting Distances in Feet" there are several spacings listed at less than 20 x 20 feet for stocks other than E.M. IX. This is to allow for the use of fillers to increase the early bearing potential of the planting. However, if these fillers are removed the permanent row spacing is 20 feet or more.

Based upon the results at this Station, from a 20-year-old planting of trees on E.M. IX, it would not appear wise to plant this rootstock closer than 15 feet between rows since it is only just possible to get the concentrate spray machine down rows set at this spacing. Similarly, for other more vigorous stocks, 20 feet is considered to be a minimum, particularly for the use of modern orchard equipment. Incidentally, for spraying the E.M. IX block at the Research Station a commercial low volume sprayer is used with the top nozzle blocked off and driven at 3.5 miles per hour. This is giving good results, including spraying for blossom thinning. Fig. 6 shows a planting of E.M. IX 10 x 8 feet where there is no room for equipment to pass between rows.

Table 2. Planting distances for various rootstocks recommended by the Research Station.

Size Group	Rootstocks	Planting Distances in Feet*	Number of Trees per Acre
Dwarf	E.M. IX, E.M. 26	15 x 8	363
Semi-dwarf	E.M. IV, E.M. VII, M.M. 106	10 x 20	216
		15 x 15	192
		17 x 17	150
		20 x 20	108
Semi-standard	E.M. II, M.M. 104, M.M. 111	17 x 17	150
		20 x 20	108
		15 x 30	96
		21 x 21	96
		24 x 24	75
		28 x 28	54
		30 x 30	48
Standard	Seedling, E.M. XVI, E.M. XXV, M.M. 109	30 x 30	48
		40 x 40	27

* Depending on soil type, existing orchard spacings and whether fillers are used.

D. Planting of trees

Clonal stocks should be handled with care to avoid drying of the roots before planting or drying of the soil in the root zone following planting. To avoid scion rooting, it is very important to plant trees with the bud union at least two inches above the permanent soil level. Yearly checks for scion rooting should be made to see that trash and soil does not build up around the tree and cover the bud union.

E. Soil management of apples on dwarfing stocks

Heavy early bearing with apples on dwarf stocks can only be achieved by developing good sized trees quickly. Nitrogen fertilizer should be applied to trees in the dormant season to produce an annual

terminal growth from two to three feet for the first four years. Fertilizer requirement may vary from 1/2 to 1-1/2 pounds of 33,0,0 fertilizer depending on tree age and soil type. Furthermore, to avoid cover crop competition the soil should be kept clean cultivated around each tree in a six-foot circle or by strip cultivation, for the first five years. Cultivation should not be continued past the middle of July; otherwise the trees may not mature early enough in the fall and will be subject to winter injury. Because of their shallow roots, dwarf and semi-dwarf trees should not be cultivated deeply.

After the trees have come into bearing sufficient nitrogenous fertilizer should be applied to induce an average annual terminal growth of 8 inches. At this time the orchard should be sown to a shallow rooted cover crop such as white Dutch clover, ladino clover, Kentucky blue grass or creeping red fescue. It is advisable to mow the cover crop twice per month during the growing season. Ladino clover has given good results at the Summerland Research Station.

F. Pruning apple trees on dwarfing stocks

All pruning is a dwarfing process and delays commencement of bearing. By means of heavy or light cutting the growth of a branch can be weakened or strengthened as the situation requires. However, in order to minimize the delay in bearing caused by pruning, cutting to develop a strong tree framework should be completed by the end of the third growing season. Accordingly, the recommendation for apples on dwarfing stocks is to start the young tree at 30 inches and prune to obtain a modified central leader and three to six wide-angled, well-spaced framework branches, the same as for a standard tree. For trees on a semi-standard stock such as M.M. 104 or E.M. II, a modified central leader plus three or four framework branches should be developed,

but for less vigorous stocks such as E.M. IX, or M.M. 106, or E.M. VII an extra two or three branches may be left at least for a few years to obtain additional yield. Figures 7 and 8 show a three-year-old McIntosh on M.M. 104 before and after pruning. Five framework branches have been selected and have been tipped lightly to allow the modified central leader to retain a slight lead. Additional shoots from the main stem which might interfere with the dominance of the framework branches have been removed. This tree has some fruit buds on it and will now settle into heavy profitable bearing.

From the time that the main branches have been selected until the tree comes into bearing the only pruning that is necessary is the removal of competing or crossing branches, narrow crotches and "twin" limbs. Light tipping back of terminal growths to induce lateral branch development to stiffen the tree and to maintain balance between framework branches may be necessary (Fig. 9). Once the tree has come into heavy bearing and the branches have been spread by the weight of cropping, then cutting the ends of main limbs to an upward growing shoot will prevent drooping and provide suitable ground clearance for equipment.

The following four sections describe, in addition, pruning systems which have become popular in Europe for dwarfing stocks. Pillar and pyramid pruning are restrictive methods suitable to intensive production. Regulated and spindel pruning involve much less cutting and promote early bearing. All these four methods should be regarded as experimental at this time.

Pruning trees by the pillar system

Whips are headed back to 30 inches at planting, Fig. 10 (A), and all laterals are cut back to 1/2 inch stubs. During the first season

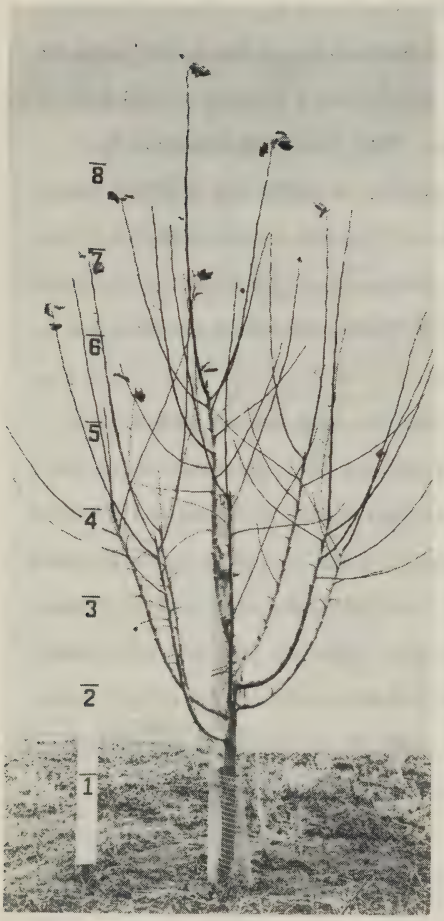


Fig. 7. Three-year-old McIntosh tree on M.M. 104 before pruning. This tree still has too many framework branches.

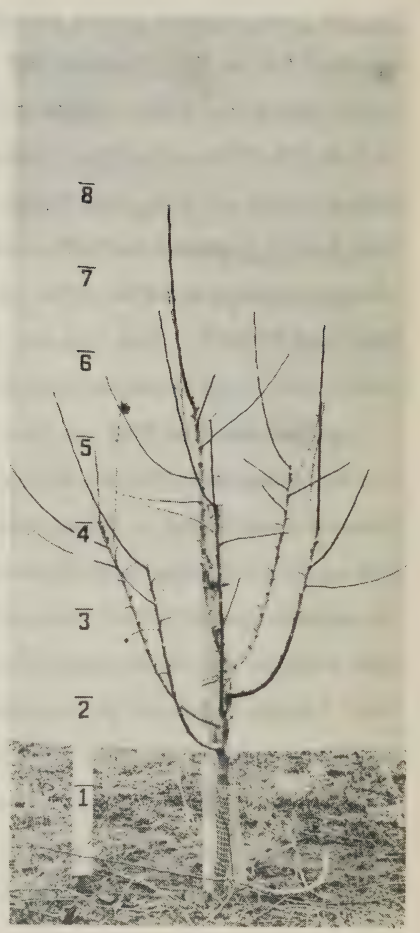


Fig. 8. The same tree as in Fig. 7 but after pruning. Pruning has consisted mainly of removal of surplus and competing branches plus light heading of remainder. The framework consists of 5 branches and the modified central leader. The framework of this tree is now established and further pruning should be light to encourage fruiting.

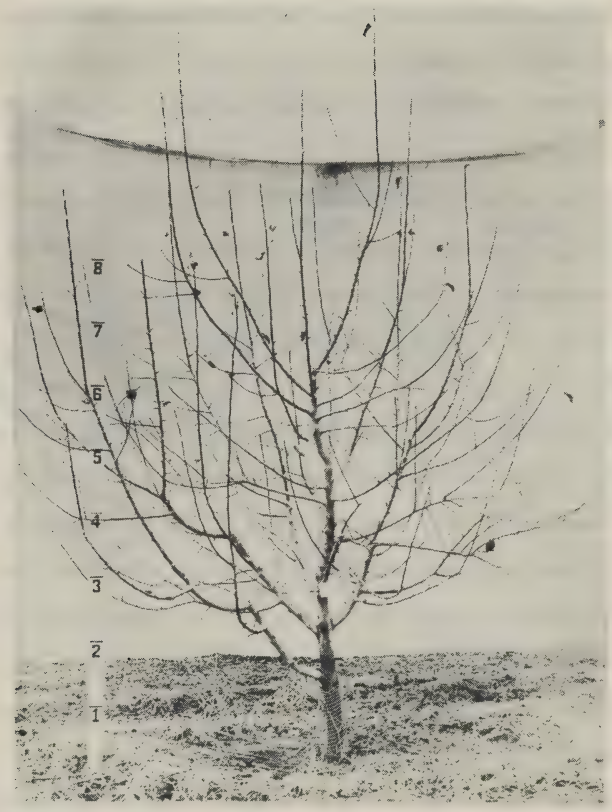
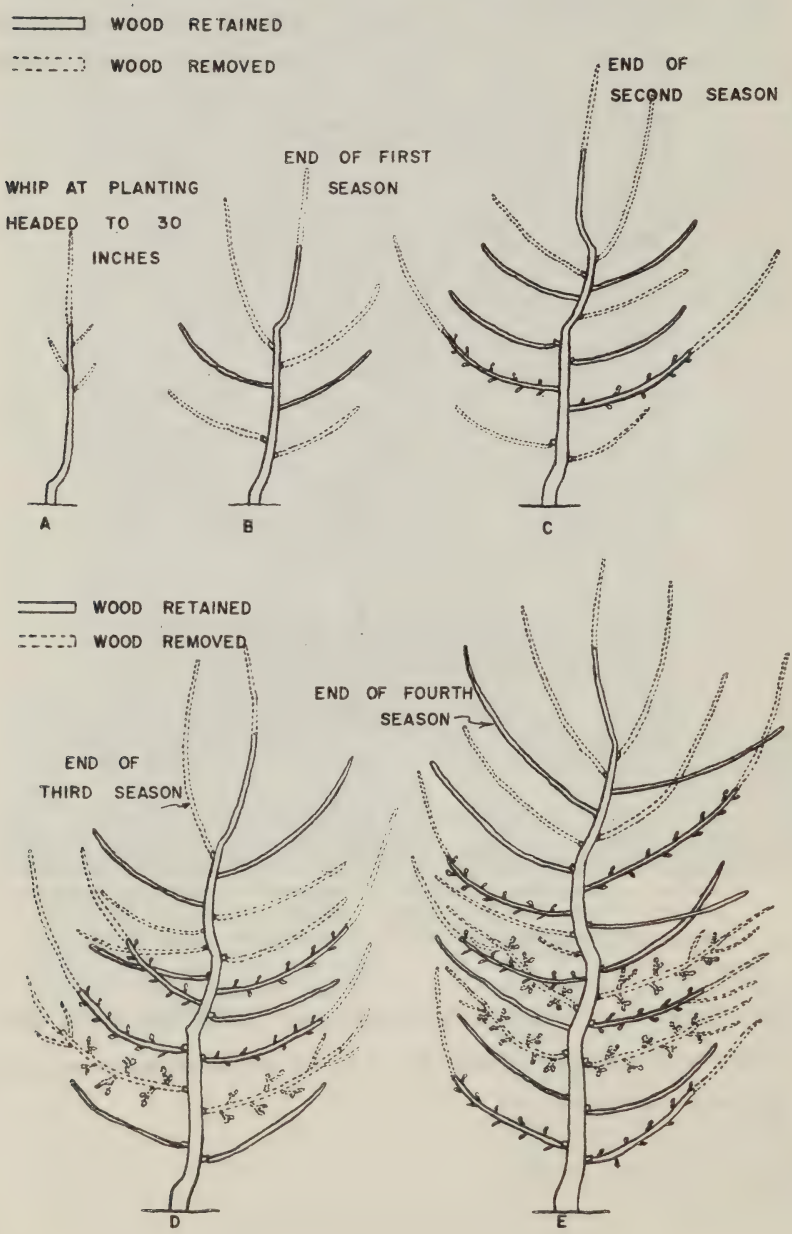


Fig. 9. Six-year-old McIntosh tree on E.M. II rootstock following light pruning. The main framework was established when the tree was in its second and third growing seasons. Current pruning has consisted of removal of competing branches, narrow crotches and twin limbs. Smaller and weaker branches have been shortened and left to increase the early yield.

the tree develops a leader with new laterals. At the end of the first growing season pruning is carried out in the following manner as illustrated in Fig. 10(B):

FIG. 10 PRUNING DWARF PILLAR APPLE TREES



1) The new growth on the leader is cut back about half-way to a bud that will keep the next season's growth upright.

2) The first lateral below the leader is always cut back to a short stub of one-half inch.

3) Of the remaining laterals, two are left unpruned while the others are cut back to stubs. If possible, the two laterals that are left should be on opposite sides of the tree and not too upright in growth. If the tree is growing strongly it is quite in order to leave three laterals instead of two.

This procedure is followed each year when pruning the leader and the new laterals immediately below it until the central stem has reached its planned height of about ten feet. An equal number of one-year laterals and two-year laterals then are retained along the central stem. After pruning at the end of the second growing season, as shown in Fig. 10 (C), the tree will consist of the shortened new leader, two laterals from the previous year's leader, a pair of two-year laterals with the terminal growth removed and two replacement one-year laterals. Thus, the pruned tree at the end of the third growing season, as shown in Fig. 10 (D), will have the leader, two laterals on the previous year's leader, four two-year laterals and four replacement one-year laterals. Three-year laterals are removed whether they have borne fruit or not.

In the third year some fruit may be produced on the three-year-old laterals. The crop will increase steadily each year as more laterals are left on the tree until the eighth year when the tree will be carrying twenty to twenty-five fruiting laterals capable of bearing a crop of forty or more pounds of fruit. At this age the tree will have reached its planned height of ten feet and the leading shoot will no

longer be necessary. It will then be cut back hard and any further laterals or shoots which develop at the top of the tree, treated as normal laterals for fruiting or stubbed back as required.

The pruning of fully grown pillar trees is carried out according to the following operations:

1) All of the three-year laterals are cut to short stubs whether they have fruited or not.

2) The terminal shoot or shoots are cut off the two-year laterals leaving the fruit buds intact.

3) The one-year laterals are thinned to give an even distribution over the whole tree leaving about twenty to twenty-five laterals that form a wide angle.

Mr. Gordon Maclean, Kingston Bagpuize, Berkshire, England, developed this system for intensive production of high quality apples and pears. He recommends a planting distance of 6 x 12 feet or 605 trees per acre for apples on seedling rootstocks. However, under B.C. conditions E.M. VII or II rootstocks would probably provide adequate vigor.

This system was developed under English conditions and would probably require modification here. For instance the tree could probably reach ten feet in height by four to six years from planting so that three to four new laterals would have to be retained each year instead of two in order that the desired amount of fruiting wood is present when the trees reach their planned height.

Pruning trees by the dwarf pyramid system

The one-year whip is cut back to twenty inches at the time of planting. Each year terminal growth on the leader should be pruned back to ten inches to encourage development of side branches and pre-

vent the leader from becoming too weak to support the crop in future years. Any sturdy wide-angled new branch arising from the leader is left unpruned for the first two years.

During the second year one of two pruning methods may be followed.

1) Any lateral growth from the selected branches is pinched back as it develops or, 2) the lateral shoots from branches are cut back to stubs three-eighths of an inch long when they reach eight to ten inches in length. At the end of the second year the new terminal growth of each branch is cut back except for the basal one inch. The main stubbed branches are maintained at this established length for their life on the tree. When the tree grows, it does so by extension of the leader or by adding to the size and/or number of spurs on the leaf rosettes. (Fig. 11). This means in practice that apart from the new terminal growth of the leader with its yearly tier of new branches, the tree is composed of stubbed branches carrying spurs bearing fruit and leaves. By this method, branches should start to bear in the third year and each additional year will bring more branches into bearing. After about eight years when the tree has attained a height of eight to nine feet, new terminal growth on the top of the tree is stubbed back to produce fruiting wood.

Mr. Eric H.M. Barker, the Englishman who popularized this modified dwarf pyramid system, considers it necessary to use a relatively vigorous rootstock such as E.M. II. One reason for using a relatively vigorous stock is to provide enough response from the summer pruning and to carry sufficient crop to make the system economically feasible. The second reason for the vigorous stock is to obviate staking.

FIG. II PRUNING DWARF PYRAMID APPLE TREES

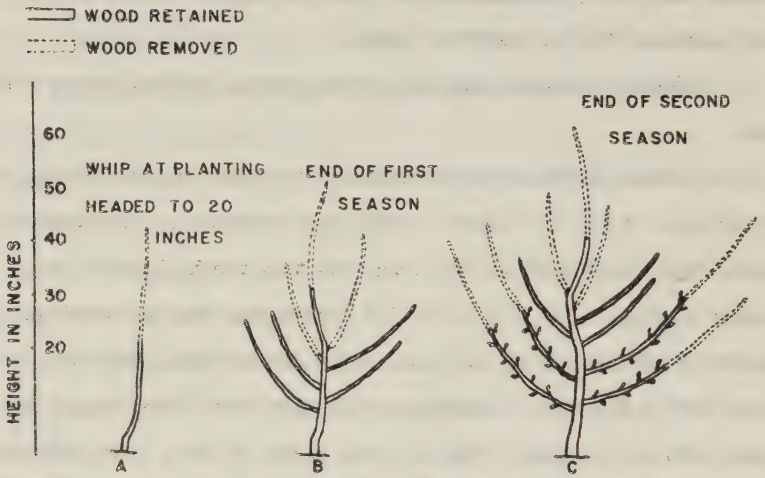
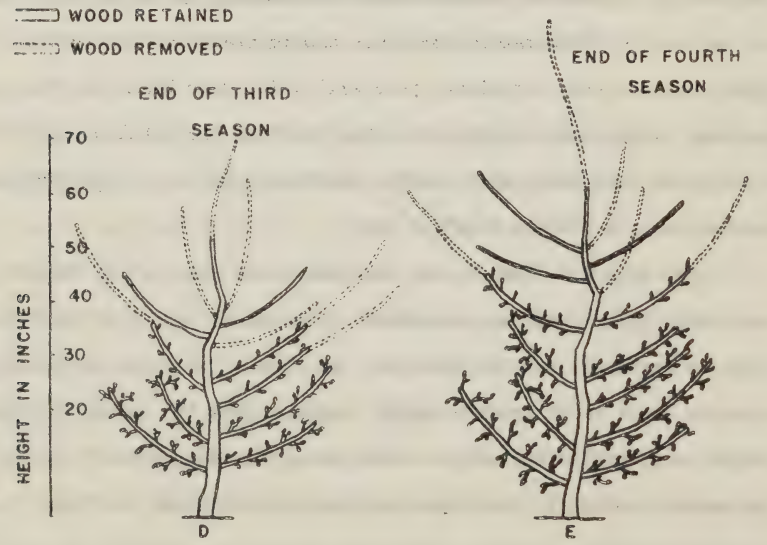


FIG. II PRUNING DWARF PYRAMID APPLE TREES



Barker proposes this as a very intensive method of culture with trees spaced at 6 x 8 feet or 907 trees per acre for apples. However, standard B.C. orchard equipment could not be used with only 8 feet between rows. A practical modification would be to place the rows at least 12 feet apart.

As our commercial varieties, climatic conditions and rootstock responses are somewhat different from those in Europe, it is probable that the dwarf pyramid pruning method may not be applicable here. With a warmer growing season than in England, irrigation and vigorous varieties such as Delicious, suckering might be so intense as to necessitate the use of a less vigorous rootstock such as E.M. VII.

Regulated pruning

Whips are headed back to 30 inches at planting time, with no attempt made to restrict the number of primary branches. During each of the ensuing two years not more than 3 leaders are tipped each year; leader tipping then ceases. Laterals are neither spur pruned nor shortened. Crowded, thin, and weak laterals, as well as those that compete with the unpruned leaders, are removed completely, irrespective of age. Any suckers present on the trunk are removed.

This pruning method will probably give heavy early yields, but the resulting tree will require fairly heavy corrective pruning in later years to provide ladder room and to decrease shading. This style of pruning should be ideal for handling filler trees where heavy early production is the main objective. An example of a five-year-old tree pruned to the regulated system is shown in Fig. 12. This photograph is taken from the 1953 report of the East Malling Research Station.

Spindel bush pruning

This system, popular in Holland and Germany, consists of heading the tree at planting to a height of two feet to encourage the develop-

Fig. 12. Five-year-old Cox's Orange tree on E.M. II pruned by the English "regulated" system. Tree is 11 feet high with 11 feet spread. Further branch removal will be required as tree grows older and crops heavily. (Courtesy East Malling Research Station).

ment of four low primary branches during the first season. At the end of the first season these four main branches are tipped back lightly and the central leader is tipped back to a height of about $3\frac{1}{2}$ feet. Branches growing upright at an acute angle and competing with the central leader also are removed.

During the second summer the four main branches which were selected are forced to grow in a horizontal position by means of wire clips or by tying the branches down with strings attached near ground level to pegs or the central post supporting the tree. This horizontal position induces the formation of fruit buds on the upper surface of

these branches. During the second summer additional side branches from the central leader are encouraged to grow horizontally by tying them with strings to the four main branches which are already in a horizontal position. Practically none of these horizontal branches from the central leader is removed, as such removal delays fruiting. In the third year the first fruit will likely appear on the primary outward-growing branches. Once these branches have come into fruiting they are tipped back lightly so as to encourage the development of upward-growing shoots which will eventually be required to replace these branches when they droop too close to the ground. In the third season all the small shoots on the tree, instead of being removed, are brought into the horizontal position by pinning them with clothespins to established branches.

Trees trained by this method, whether they be on E.M. II, IV, VII or IX bear heavily by the fifth year. Eventually, when the central leader reaches a height of 10 feet it is headed back lightly. There is a great deal of summer work to this method but on the other hand it must be remembered that little winter pruning is done and the four primary branches have to be tied down only once. After that the clothespin method of bringing the smaller shoots into the horizontal position can be performed rapidly.

All trees on E.M. IV or IX stocks are supported with permanent stakes standing about six feet above the ground. Other stocks are supported only for the first few years after planting. Production by the spindel bush method of pruning is about five hundred bushels per acre at five years.

For a straight E.M. IX planting the suggested spacing is 13 feet between the rows and 6½ feet between trees for moderately vigorous varieties such as Cox Orange and Jonathan but slightly wider spacings for McIntosh and Delicious. Where E.M. II is used as a rootstock in a permanent planting the trees should be planted about twenty-two feet apart.

Fig. 13. Four year old Golden Delicious tree on E.M. IX trained by the spindel bush method. Note the staked central leader and the branches tied down to induce fruiting.

In Holland there is considerable interest in the "mixed Spillen system" in which permanent E.M. VII trees are planted 10 feet apart in rows 16 feet apart. Filler E.M. IX trees to be removed after seven years are planted between the E.M. VII trees in the rows. Fig. 13 shows a four year old spindel bush tree of Golden Delicious on E.M. IX.

G. Irrigation of apples on dwarfing stocks

Irrigation of semi-standard apple trees, such as those on E.M. II or M.M. 104, when grown similar to standard trees, constitutes no real problem because spacing is sufficient to permit either furrow irrigation or under-tree sprinkler irrigation. A bulletin, "Sprinkler Irrigation of Tree Fruit and Vegetables in British Columbia", by J. C. Wilcox, available at the Summerland Research Station, deals thoroughly with problems of orchard irrigation. If semi-standard trees are planted very close together, however, and are trained by the "pillar" or other methods not presently in use, special methods of irrigation might have to be developed.

Dwarf trees, such as those on E.M. IX, constitute a special problem. They have shallow roots, so furrow irrigation should be used

only with caution and since the trees are closely planted, under-tree sprinklers are not always satisfactory. Where sprinklers are placed in every second row, the low growth on the trees prevents water reaching satisfactorily into the adjoining rows.

Over-tree irrigation for dwarf trees provides a solution, but has disadvantages due to effects of wind on water distribution, and because of the possible presence of the Phytophthora organism in the water. Phytophthora can cause crown rot as well as rotting of peach, apricot, pear and even apple fruits. In spite of these difficulties, a dwarf block at the Research Station has been irrigated successfully by this method for some years. Several growers are also using over-tree irrigation in dwarf plantings.

Giant type high pressure sprinklers are not recommended for use in over-tree irrigation. At the Research Station a block of trees on E.M. IX is irrigated with overhead sprinklers on eight-foot stands located 50 x 50 feet apart and delivering water at 50 pounds pressure. Water is supplied to the sprinklers by plastic hose. Growers use adaptations of this general type. Fig. 14 shows an example of a portable aluminum

Fig. 14. A portable aluminum overhead sprinkler used to irrigate apples trained on the cordon system. Note that the sprinkler height can be changed by adding on or removing short sections of riser.

Fig. 15. Young Golden Delicious trees on E.M. VII rootstocks trained on a cordon system. The trees are spaced 8 feet apart in rows 11 feet apart. Mr. L.L. Van Roechoudt of Doornberg Orchards, Okanagan Centre, B.C., in foreground.

overhead sprinkler used in a block of Golden Delicious trained on a cordon system.

The best method of irrigating semi-dwarfs such as E.M. VII will depend on their spacing and method of training. If the trees are planted close together, are bushy and not too high, over-tree irrigation might prove suitable. Otherwise, regular sprinkler irrigation should be used where possible in preference to furrows.

The more dwarfing the rootstock, the smaller the leaf area per tree and the shallower the roots. If the trees are planted close together they may eventually require about as much irrigation water as standard trees. Because they feed on less soil, however, they need more frequent irrigation with lesser amounts of water at each irrigation.

H. Staking or supporting of trees:

Trees grown on many E.M. and M.M. rootstocks require support at

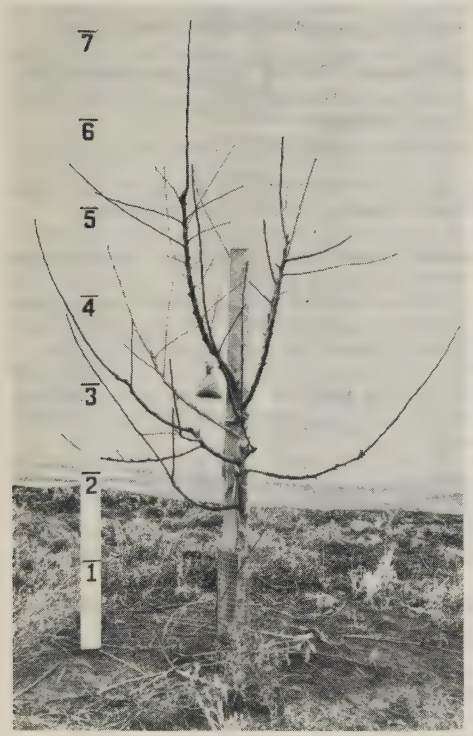


Fig. 16. A young Winesap tree on M.M. 106 at the end of the third growing season. Note the sturdy, split cedar stake supporting the tree. This stake will probably last as long as support is necessary. A cotton sack of blood and bone meal deer repellent is hanging in the tree.

least in the first years after planting. Trees on M.M. 104, E.M. XVI and E.M. XXV, however, may not require any staking, but those on E.M. II, M.M. 111 and M.M. 109 will require staking if the trees begin to lean, especially after a heavy irrigation followed by strong winds.

Trees grown on E.M. IX and E.M. 26 stocks require permanent support, the nature of which will depend on the training system employed. Trees trained to a normal symmetrical form can be supported either by wires on posts in the row or by individual stakes, while those trained to a cordon system will have to be supported on wires, as seen in Fig. 15.

Any training system for trees on clonal rootstocks which permits individual tree staking probably will be much cheaper than wiring because of lower initial cost and lower costs for cultivation and management during the early years of the planting. A good example of individual tree staking is seen in Fig. 16.

Where wires are used for supporting dwarf trees as in cordon sys-

tems, heavy cedar posts 7 feet high above ground, spaced about forty feet apart in the row carrying one, two, or three wires similar to that used for grapes, will be sufficient. In any case the first wire should start at 2½ feet above ground level.

I. Use of hardy frameworks

Permanent trees of varieties ripening later than McIntosh should be worked on a hardy framework where semi-dwarfing, semi-standard and standard stocks are used. Trees on full-dwarfing stocks are seldom double worked, since replanted trees resume bearing at an early age. Filler trees are temporary and are grown only to increase early yields and do not warrant double working.

VI. REVIEW OF EXPERIMENTAL RESULTS FROM THE RESEARCH STATION, SUMMERLAND

In Summerland Research Station Publication 898 published in 1953, Mann and associates indicated that there was practically no production on McIntosh and Delicious trees on E.M. IX for the first six years, but starting in the sixth season from planting, production was consistent and increased slightly up until the fifteenth year when the data was summarized. (Early yields in these trials were probably lowered by use of more severe pruning practices than are now in vogue.) On McIntosh, the average yield per tree was 47 pounds, and on Delicious 39 pounds per tree per year. Based upon a planting of 363 trees per acre this represents average production during this period of 426 and 354 boxes per acre respectively.

A later summary of data published by Weiss in the Canadian Fruit Grower in 1957 gave yields over a 20-year period for McIntosh, Delicious, Winesap and Rome Beauty planted in 1938 on E.M. IX. These data plus the accumulated yields up to the twentieth year are presented in Table 3, along with a comparison of yields from trees on a seedling rootstock for

the same age. On an acre basis it can be seen that trees on E.M. IX rootstock have outproduced trees on seedling rootstocks in every case except Delicious. Production of Delicious on seedling rootstock exceeded that on E.M. IX rootstock from the fifteenth to the twentieth year. It is quite possible that the cumulative yield, if it could be projected for the years between 20 and 30 from planting, would show that the trees on seedling stocks exceeded yields of trees on E.M. IX rootstocks. On the other hand, trees on E.M. IX rootstocks provided advantages in controlled tree size and cheaper orchard operation. In addition, slightly earlier maturity of fruit in late seasons is an important advantage for trees on E.M. IX stocks.

Table 3. Yields per acre, in 40-lb. boxes, for trees on seedling and on E.M. IX rootstocks. (Research Station, Summerland, orchards 9A and old 9D.)

Variety	Rootstock	Two-year yields at the following ages								
		2&3	4&5	6&7	8&9	10&11	12&13	14&15	18&19	Cumulative 1-20
McIntosh	Seedling	0	41	146	237	312	392	434	806	6768
"	E.M. IX	56	146	307	335	383	803	848	1166	9333
Delicious	Seedling	0	3	46	150	279	477	632	1096	7242
"	E.M. IX	38	80	214	209	435	533	472	629	6984
Winesap	Seedling	0	8	35	90	149	223	338	542	3617
"	E.M. IX	80	171	284	337	645	698	619	829	9306
Rome	Seedling	0	10	111	139	184	298	468	572	4900
"Beauty	E.M. IX	113	104	154	165	518	618	529	827	7857

Trees on seedling stocks planted 30 x 30 feet.
" " E.M. IX " " 8 x 15 feet.

Trees on E.M. IX, II, XVI and seedling stocks

A summary of 20-year yields for McIntosh and Delicious trees planted on E.M. IX, II, XVI, and on seedling rootstocks at the Research

Station, given in Table 5, shows that trees on E.M. IX have outproduced all other stocks by a substantial margin with both varieties. This is in contrast to data in the previous table where Delicious on standard roots outproduced E.M. IX in the latter part of the period. It should also be noted that had trees on E.M. II been planted at the currently recommended 108 instead of 70 trees per acre, yields probably would have been comparable with those from trees on E.M. IX.

Table 4. Cumulative yields per acre in 40-lb. boxes of Delicious and McIntosh on four rootstocks. (Research Station, Summerland, orchards 9C and 9A.)

Rootstock	No. of trees per acre	Boxes per acre for the periods				
		1-5th yr.	1-10th yr.	1-15th yr.	1-20 yr.	16-20 yr.
		Delicious				
E.M. XVI	48	0	456	1628	3668	2040
Seedling	48	0	368	1384	2972	1588
E.M. II	70	6	578	1970	4293	2323
E.M. IX	363	210	1287	3828	6984	3156
		McIntosh				
E.M. XVI	48	2	971	2402	5056	2654
Seedling	48	20	926	2439	4618	2179
E.M. II	70	75	1339	3741	6331	2990
E.M. IX	363	423	1674	4797	9333	4536

Research station off-station plantings and observation plots

Information gathered on the off-Station Dwarf Orchard Survey initiated in 1956 and maintained annually, shows many interesting trends. The first and most significant is that trees on the dwarfing stocks require greater care and attention than trees on seedling rootstocks. These shallow rooted stocks cannot compete with weeds and grass for moisture and nutrients as favorably as trees on more vigorous seedling stocks. It has been noted that trees on dwarf stocks frequently require

extra watering and cultivation. A careful mulching program is often beneficial in reducing winter injury and weed and grass competition. Trees on dwarfing stocks do not do well as interplants in an established orchard or in locations shaded by larger trees. It is preferable, therefore, that trees on dwarf roots be planted in solid blocks.

Growers who have given trees on dwarf stocks the required care have been rewarded by good growth and very promising early yields. However, there are plantings in the Okanagan Valley that are dismal failures and many others which are headed in that direction unless the growers involved make radical changes in their methods of culture.

Yields from some of these grower orchards are presented in Table 5, where orchards are rated good, fair, or poor depending on the evaluation made during the survey. The data are not complete for the early years in some blocks because crops were not recorded by many growers prior to the initiation of the survey. The table is intended to show some of the yields obtained by growers using various variety-rootstock combinations. At the present time there has been no attempt to compare yields obtained from trees trained according to different methods.

Outstanding differences in yields between orchards rated good and poor are readily seen in Table 5. For example, Red Delicious on E.M. VII at 6 years from planting produced 392 boxes per acre in a good orchard and only 36 boxes per acre in a poor orchard, while Spartan on E.M. I produced 761 boxes per acre in the ninth year in a good orchard and only 130 boxes per acre in a fair orchard.

Table 5. Yields in 40-pound boxes per acre from trees on various root-stocks at the following years from planting.

Variety	Root-stock	Orchard Rating	Years from Planting										
			3	4	5	6	7	8	9	10	11	12	13
Winesap	E.M.II	Fair		72	232	46*							
		Poor		12	56	56							
Winesap	E.M. VII	Good	34	48	154	600	121*						
		Fair				206	331	460	660	777	680	695	
		Poor			12	60	56						
Red Delicious	E.M.II	Good		243	405								
		Fair			60	90	219	185	377	416			
		Poor				36	102						
Red Delicious	E.M. VII	Good	8	27	93	392	27*						
		Fair				241	405						
		Poor				36	102						
Spartan	E.M.I	Good							761	1052	883	644	1241
		Fair				17	49	123	130	403	206	431	431
Spartan	E.M.II	Good								763	696	707	
Spartan	E.M. VII	Good						75	411	159	308	486	
		Fair								428	399	177*	
Golden Delicious	E.M.IX	Good		683	536	1321							
		Poor		27	75	120							

* Denotes loss of crop due to frost injury.

VII. COMPARISON OF ESTIMATED CUMULATIVE YIELDS FOR COX'S ORANGE PIPPIN ON VARIOUS E.M. AND M.M. ROOTSTOCKS AT THE EAST MALLING RESEARCH STATION, ENGLAND

Data in Table 6 gives the estimated cumulative yields of Cox's Orange Pippin in bushels (40 lb.) per acre at six and eleven years from planting at the East Malling Research Station on various E.M. and M.M. rootstocks. Substantially similar data have also been obtained at East Malling with two other scion varieties. These data are for a moderately vigorous variety grown under cultural methods different from those practised in the Okanagan Valley, but are very useful for comparing the performance of one rootstock with another. The data are particularly interesting since there are no bearing trees on the M.M. rootstocks in the Okanagan Valley.

Table 6. Estimated cumulative yields per acre in bushels (40 lb.) at appropriate spacing for trees on loam soil*

Rootstock	Distance apart in feet	Number of trees per acre	Cumulative yield from planting	
			at 6 years	at 11 years
E.M. IX	12	302	543	1,313
E.M. VII	15	193	699	1,987
M.M. 106	15	193	699	1,785
E.M. IV	17	150	645	2,066
E.M. II	17	150	416	1,646
M.M. 111	17	150	585	2,242
M.M. 104	17	150	675	2,666
M.M. 109	24	75	210	984
E.M. XV	24	75	262	1,125
E.M. XVI	24	75	180	660

* Reproduced from the Annual Report of the East Malling Research Station for 1958.

VIII. ACKNOWLEDGEMENTS

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